# APPENDIX A

## Additional Evaluations for the 2007 Houston Attainment Demonstration

## HOUSTON/GALVESTON ATTAINMENT DEMONSTRATION - PART II

## OCTOBER 1999 REVISION

RADIAN INTERNATIONAL
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# MEMORANDUM

**To:** Bill Gill (TNRCC)

**From:** Rick Baker (Radian)

**Date:** 18 June 1999

**Subject:** **Additional Evaluations for the 2007 Houston Attainment Demonstration**

**CC:** Lily Wells (H-GAC), Mary McGarry-Barber (TNRCC), Sam Wells (TNRCC), Jim Smith (TNRCC), Jim MacKay (TNRCC), Jim Neece (TNRCC), Charlie Rubick (TNRCC), Wayne Young (TNRCC), Mike Magee (TNRCC), John Taunton (Exxon), Craig Beskid (Radian), Sandeep Kishan (Radian)

Radian is currently under contract to the Houston-Galveston Area Council to identify and evaluate potential means of assisting with the TNRCC's 2007 attainment demonstration for Houston. Potential options include identifying and quantifying additional, creditable NOx controls; improvement of the base and/or future year emission inventories; and modification of the temporal/spatial allocations used in the development of the UAM input files. This analysis is limited to potential NOx reductions from on and off road mobile sources.

As part of this effort Radian worked closely with TNRCC staff as well as other interested parties to identify potential adjustments to the current EI. As a first step, we compiled a list of the key assumptions used to develop the base and future year NOx emissions inventories for construction and commercial marine sources operating in the Houston ozone non-attainment area. The methods used to spatially and temporally allocate these emissions for UAM applications were also determined. The list was intended to allow local experts, as identified by H-GAC, to recommend means of improving the current EI and/or UAM inputs for these source categories. The reviewers were also asked to specify the length of time required to gather and QA the necessary data and supporting documentation. Simple analyses that could be performed using existing data sources were performed under this contract by Radian (see Findings below), while more involved research and quantification efforts are deferred to the 4 to 8 month timeframe (see Additional EI Modifications below). Please see Attachment 1 for the listing of key assumptions used to develop the EI/UAM files.

Radian, TNRCC and H-GAC also worked together to identify and quantify additional NOx control measures for on and off road sources. For each measure we developed "first-order" benefits estimates, incremental to controls included in Scenarios 1 through 8 in TNRCC's previous UAM modeling exercise. Additional modeling and/or research may be needed in order for certain measures to receive full credit from EPA.

The following provides a summary of Radian's findings, a discussion of the methodology and assumptions used in the modeling, and a brief discussion of other technical, regulatory and enforcement issues. In addition, we discuss certain modifications made to TNRCC's original EI

calculations. Finally, we provide a set of potential action items for the next 4 to 8 months, based on input from the peer reviewers and our own assessment.

(Finally, please note that the inclusion or exclusion of any particular control measure herein does not imply official endorsement by the H-GAC or the Greater Houston Partnership – such assessments will be made during the subsequent analysis period.)

## FINDINGS

Table 1 summarizes the emissions inventory adjustments and the estimated incremental reductions applied to the 2007 base case NOx inventory for sources operating in the Houston-Galveston nonattainment area. Many of the controls evaluated were already included in TNRCC's modeling Scenarios 1 – 8, and were collected from TNRCC modeling staff files (1993 – 2007 Growth and Control Packet Files for COAST Domain HG and BPA Modeling by MCNC – May 7, 1999). In conjunction with TNRCC and H-GAC, Radian developed adjustments to some of these factors, as well as reduction estimates for additional control measures. Note that even after the addition of several new control options and certain downward adjustments to activity and emission factors, the projected inventory is still about 100 TPD too high in order to demonstrate attainment under existing modeling assumptions.

EI Adjustments: After review of the modeling factors used to develop the MCNC scenarios, Radian recommended 4 adjustments, including changes to:

- Tier 2 vehicle and low-sulfur/Cal RFG impacts;
- Reductions associated with an eight county 55 MPH speed limit;
- Seasonal allocation of construction activity; and,
- IM240 emission benefit calculations.

1. Tier 2 / Low Sulfur Fuel -- As part of a recent study for TNRCC, Radian estimated the emissions benefits for Harris County resulting from the newly promulgated Tier 2 and low sulfur gasoline standards, incremental to the NLEV program with federal RFG. Attachment 2 provides a detailed description of the methodology used to develop these estimates. As part of the current effort Radian updated the previous calculations to include the surrounding seven county region. In addition, Radian modified the I/M assumptions to be consistent with the MCNC modeling scenarios.[1] The net effect was estimated to be 19.8% (weighted average for the 8 county area). This is slightly greater than the 17% reduction previously reported by Radian and used in the MCNC modeling.

[1] Radian had previously assumed "Max I/M" for NLEVs in our modeling. However, given the order of the factors applied in the MCNC scenarios, the baseline for estimating Tier 2 effects was changed to the current Texas Motorist Choice program – IM240 benefits were applied later in the analysis.

However, previous scenarios had assumed that there was a benefit associated with the use of California RFG, incremental to the above adjustments. Since Cal RFG is essentially identical to the federal low-sulfur gasoline proposed by EPA, this resulted in double counting of fuel effects. Specifically, the previous analysis estimated a net reduction of approximately 26% after all vehicle standards and fuel effects, compared to Radian's new estimate of 19.8%. The adjustment results in about a 16 tpd increase in emissions estimates.

2. 55 MPH Speed Limit -- TNRCC Mobile Source Section staff recently estimated that the weighted-average vehicle speed for the 8 county area would only fall from 48 to 46.5 with the adoption of a 55 MPH limit.[2] Radian estimated a very small NOx benefit associated with this shift – about 0.6%. This is much smaller than the 6.7% claimed in the previous modeling scenarios. Upon discussion TNRCC staff agreed that the revised estimate is much more representative of real-world impacts. (Note, however, that Radian did not perform a link-based time-of-day analysis for this measure – since speed effects NOx emissions non-linearly, actually emission reductions may be slightly higher, but still close to 0.6%.) The adjustment results in about a 16.5 tpd increase in emissions estimates relative to previous values.

3. Seasonal Adjustment in Construction Activity -- Previous UAM modeling runs have assumed the same activity for construction sources, regardless of the time of year modeled. However, the base year non-road construction inventory is taken directly from NEVES, which provides estimates for typical ozone season days (OSDs). OSDs are defined as weekdays between June and August. However, the key modeling runs of interest occur in the month of September. Both NEVES and the new NONROAD model assume specific adjustment factors for Fall construction operations, for Southwest regions of the U.S. including Texas. While the three summer months are assumed to contain 1/3 of total yearly activity, the six fall and spring months account for only about 46.8% of all activity. Therefore construction emissions for the September modeling runs should be decreased by a factor of 0.078/0.11, or about 30%.

Radian agrees with TNRCC staff that this "step function" approach to activity allocation is arbitrary and unrealistic – activity in early to mid-September is likely to be almost the same as in August, especially for warm areas like Houston. However, until site-specific activity data can demonstrate to the contrary, seasonal allocations should be applied as per EPA guidance. This adjustment results in about a 30 tpd decrease in emissions estimates relative to previous values.

4. 8-County IM240 Benefits -- Radian used MOBILE5b input files provided by the TNRCC to model the IM240 benefits for the 8-county area. Given Tier 2/low sulfur and other minor adjustments, Radian estimated a slightly greater IM240 benefit than previously estimated – about a 5.3 tpd reduction compared to previous estimates.

Incremental Control Effectiveness: Radian worked closely with the TNRCC as well as H-GAC and other interested parties to identify additional creditable control measures beyond those

[2] Since the majority of VMT occurs during slow-speed rush hours, most vehicle travel remains unaffected.

included in MCNC Scenario 8. Although numerous potential measures were identified, only a few were amenable to analysis in the two week time frame available. In addition, Radian calculated significant, creditable emission reductions for only two of these measures – increased IM240 stringency and the adoption of California diesel fuel specifications. The numerous other measures evaluated are discussed in more detail in the following section.

1. Increased IM240 Stringency -- The only additional measure Radian identified for on-road vehicles was to make the modeled IM240 program more stringent. For Tier 1 and earlier vehicles (up to and including model year 2000), Radian selected the most stringent NOx cutpoint modeled by TECH5, 1.5 gpm, compared to 2.0 as specified under the performance standard. Model years 2001 and later will meet LEV or better standards under the NLEV and Tier 2 standards. Therefore these vehicles are eligible for "Max I/M" credits, wherein I/M programs utilize advanced OBD2 and other mechanisms to drastically limit emissions deterioration over the useful life of the vehicle. Adopting both of these options for the eight county area will generate an additional 17% NOx reduction relative to the standard IM240 previously modeled (i.e., about 27 additional TPD). However, detailed analyses of the incremental change in errors of commission would be needed before adopting these tightened cutpoints.

Note: While the validity of the Max I/M assumption is considered suspect, Radian believes that any over-estimation of emissions credits under this program will be somewhat (or entirely) offset with the adoption of MOBILE6 in the near future, given the dramatically lower deterioration rates expected for advanced technology vehicles.

2. California Diesel Fuel Use in Off-Road Applications -- Previous MCNC modeling scenarios already include the effect of adopting the California diesel engine standards, relative to the new federal standards (weighted average of 8% reductions across all equipment types in 2007, according to TNRCC staff). However, additional benefits may be accrued by adopting low-aromatic diesel fuel specifications as well. EPA has approved California ARB's claim of a 7% NOx reduction associated with using 10% aromatic diesel fuel in pre-electronic control diesel engines, relative to the industry average of 35% aromatics (personal communication, Archana Agrawal, California ARB, 6/8/99).[3] Use of this fuel is creditable for most non-road sources, excluding aircraft, marine vessels and locomotives, whose operations render control of refueling practices impractical. Nevertheless, limited benefits were claimed for certain marine engines, as explained below.

Radian assumed the same 7% reduction would be applicable in Houston, even though we were not able to obtain aromatics percentages for the area. (Bruce Anderson of Starcrest Consulting Group reported that marine diesel used at the Port was approximately 35% aromatics, although

[3] Although approved by EPA, this credit is based on a very limited data set, comprised entirely of on-road heavy-duty engine tests. In addition, no 2-stroke diesel engines were included in the data set, so the application to marine engines is even more uncertain, although the EPA credit extends to 2-strokes as well.

he could cite no test data to this effect – personal communication, 6/3/99). TNRCC may wish to confirm this assumption before formal SIP submittal.

In order to calculate fuel reformulation benefits, Radian used data from the 1993 Periodic Emissions Inventory from TNRCC to estimate the percentage of total NOx emissions from diesel fuel for each source category. While most non-exempt sources were nearly 100% diesel (w.r.t. the NOx inventory), industrial sources (at 59%) and light commercial sources (at 84%) did require adjustment accordingly. As an additional step, Radian also had to allocate emission reductions resulting from the adoption of the California off-road diesel engine standards across the different source types, before applying fuel benefits, since the 8% figure provided by TNRCC was a weighted-average value across all source categories. This allocation assumed a simple weighting based on percentage of emissions from diesel sources, although actual reductions will vary depending on equipment type and standard phase-in schedule. Also, an additional source of error is introduced since there are likely to be fuel and technology shifts within a given sector between the 1993 base year and 2007. (Note that this type of shift is accounted for in the new NONROAD model). Therefore we suggest TNRCC refine this portion of the analysis before SIP submittal.

Finally, Radian estimated NOx reductions for the canal (19 tpd baseline EI) and harbor (7 tpd baseline EI) vessels in the commercial marine category, assuming the use of low-aromatic diesel. However, only captive vessels could be effectively required to use a specific fuel by local mandate. Therefore, depending on the ultimate fate of the upcoming federal clean diesel standards, the credit claimed for these sources (1.67 TPD) could fall dramatically. (See the following section for a detailed discussion of this topic.)

## ADDITIONAL EI MODIFICATIONS AND CONTROL MEASURES

As noted above, several additional control measures and improvements to the emissions inventory were identified during the course of this analysis that were not possible to evaluate in a two week period. The following discusses the possibilities for further reductions/adjustments, on a source-by-source basis. In addition, those measures that were deemed inappropriate for further analysis are also discussed.

Commercial Marine Sources: Radian participated in multiple conference calls with representatives of the Port of Houston, H-GAC and the TNRCC regarding the commercial marine inventory and potential control options. The first conference call on May 26 discussed the potential for adopting operational modifications at the Port as a control technique. Laura Fiffick with the Port summarized the measures that have been evaluated by the Port of Long Beach in California, commenting on each measure's "transferability" to Houston. These measures are discussed briefly below.

- The Port of Long Beach has adopted regulations reducing vessel speed near land as a means of reducing engine loads and therefore NOx. However, the Port indicated that vessel speeds in and around the ship channel are already strictly controlled under safety regulations (not a concern in Long Beach, which has no significant channel). Therefore this option is essentially pre-empted for the Port of Houston.
- Long Beach also evaluated modifying the location of the shipping lanes themselves to minimize emissions in critical areas. Again, given the constraints of the ship channel, this measure is not applicable to Houston.
- Actual engine shut-downs, or "cold-ironing" was also evaluated in Long Beach. In this case vessels would have to rely on electricity from the docks themselves, which requires extensive infrastructure investments before adoption. SCAQMD did not adopt this measure due to its extreme economic costs. (Port representatives also pointed out that restarting a marine diesel engine can take up to a full day, which would negate a good portion of the theoretical emission reductions.)
- Finally, episodic controls such as closing the Port on ozone action days, while technically feasible, are an extraordinarily expensive proposition, given that the opportunity cost of holding commercial vessels off-shore or away from the dock averages about $10,000/hour. SCAQMD rejected this option for economic reasons.

After a brief discussion it was agreed by all parties that these measures were not feasible for the Port of Houston. However, Port representatives did acknowledge the technical feasibility of using "clean diesel"[4] as a limited control strategy, at least for tug and tow boats.[5] At this time it was agreed that Radian should evaluate the use of clean diesel in these applications as part of the current analysis. In addition, TNRCC staff expressed an interest in establishing retrofit programs for many of the larger engines. Given that such measures would be voluntary and are therefore limited in their credit potential, it was agreed to postpone this evaluation to the 4 to 8 month timeframe.

Radian held a subsequent conference call on June 2 with TNRCC and representatives of Hollywood Marine, an operator at the Port, to discuss the overall feasibility, costs and benefits of a limited clean diesel program. Hollywood Marine expressed a suspicion that the marine inventory was dramatically overestimated relative to the locomotive inventory, given that both sources often utilize very similar engines. No specific commitments were made to look into this, however. In addition, there was some brief discussion of the potential benefits of long-term modal switching from trucking to barge container traffic. While all parties agreed this was a potentially cost-effective measure, the timeframe for any analysis was assumed to be well into the future.

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[4] In this context "clean diesel" refers to low-aromatic fuel, not necessarily a low-sulfur fuel.

[5] While ocean-going ships generally utilize residual (or bunker C) fuel oil, switching to diesel is often feasible. However, these vessels have equal access to refueling at international ports, and therefore their fuel quality cannot be mandated or controlled at the local, state or even national level. Therefore fuel controls for these vessels were not discussed further at this time.

Regarding the use of clean diesel, Hollywood Marine acknowledged that there should be no technical problems associated with such a switch, although there are economic and regulatory concerns. Specifically, at this time the clean diesel available at the Port (in this case meaning low-sulfur diesel – low-aromatic fuel is not currently available) is subject to on-road taxes, essentially doubling fuel costs. In addition, Hollywood Marine also pointed out that the vast majority of tugs and tows are not "captive" to the Port, but often refuel all along the Intercoastal Waterway, and even in New Orleans. Therefore clean diesel would only have a significant effect on these vessels if the fuel requirement were national.

As an interim approach, Radian agreed to estimate the NOx reductions for all tug and tow engines assuming federal low-aromatic fuel regulations are adopted (1.67 tpd for all canal and harbor vessels[6] – see Table 1). However, while EPA's recent Advanced Notice of Proposed Rulemaking (ANOPRM – Federal Register, May 13, 1999) clearly intimates that there are likely to be drastic reductions in diesel sulfur levels in association with the Tier 2 rulemaking, it is unclear as to their interest in lowering aromatics as well – the key reformulation for NOx control in off-road sources. Given Hollywood Marine's estimate that the true "captive fleet" may actually contain less than 10 vessels, the emission reductions from strictly local control of fuel sales would become negligible.

In subsequent conversations TNRCC staff expressed an interest in evaluating several other control options and inventory adjustments in the 4 to 8 month analysis period. These included the following:

- Possible use of clean diesel during hotelling operations for all vessels. Note that the benefit for canal and harbor vessels above already accounts for hotelling emissions.
- Benefits of fuel switching from residual to clean diesel, or even regular diesel, for ships. Again, regulatory authority is in question for this measure.
- Update the projected year inventory using the latest Waterborne Commerce activity data, as well as the Lloyd's of London database correlating engine and fuel type with specific vessels (available from the Port). TNRCC staff will take the lead on this.
- Update the projected year inventory to account for the adoption of new federal standards for commercial marine engines in the 2004 – 2006 time frame. It was agreed that corresponding emission reductions are likely to be quite small, given the very slow turnover of the engine population, and assessment should be deferred to the 4 to 8 month timeframe.

[6] The base year EI for canal and harbor vessels includes a number of small cargo vessels in addition to the tugs and tows (all less than 12 feet of draft). However, according to Laura Fiffick of the Port, it is reasonable to assume that these small cargo vessels refuel only at domestic ports, and can therefore be treated in the same way as other canal/harbor vessels, assuming federal low-aromatic fuel is adopted.

Finally, there were no comments expressed from anyone regarding the use of flat temporal activity allocations, or the REMI/EGAS growth factors for marine vessels. So we assume that these parameters are generally acceptable as is.

Construction Sources: Radian received varying degrees of input on this topic from TNRCC staff, H-GAC, the City of Houston, and Haliburton. There was a general consensus to utilize site-specific data in place of national or regional default data whenever feasible, in order to refine the current base and projected year inventories. The majority of the conclusions described below were developed during a conference call on June 8 with TNRCC and H-GAC staff. The discussion includes sections on growth factor updates, improvement of population and activity estimates, and spatial/temporal allocation surrogates.

1. Growth Factor Assessment -- The current NONROAD model, which was used to project future growth for many nonroad sources, applies a national level growth factor of about 3% per year for construction activity. This figure is an annual average value estimated for the period between 1996 and 2010 – very close to the 1993 through 2007 period of interest here.

In order to estimate growth factors specific to the Houston area, H-GAC recommended evaluating their in-house employment data by 4-digit SIC for the CMSA and surrounding region. However, reliable data is available only for the years 1995 and 1997, which is inadequate for performing the accurate time series analyses needed to estimate growth in activity.

As an alternative, City of Houston representatives suggested that Radian evaluate construction permit data from 1980 through 1995. Data for permit values at the county level for single family, multi-family, and non-residential construction are available on-line from the Texas A&M Real Estate Center. In this case the dollar value of permits was assumed to be an adequate surrogate for construction activity, as opposed to equipment population estimates used in the NONROAD model.

Radian performed a "first-order" analysis of this data by aggregating all three permit types together by year, as well as aggregating all seven outlying counties together. By splitting the data set into two regions, we hoped to obtain a rough estimate of the geographic variation in growth. This approach was taken because it is expected that construction activity is generally shifting, in ring-like fashion, away from the center of the modeling region. This shift may cause a net impact on UAM outputs, even if total inventory estimates remain the same.

Radian then performed a simple linear regression analysis on the two time series to estimate a predictive relation between real dollar values and time. After initial analysis Radian concluded that data prior to 1987 skewed the results dramatically, due to the "oil patch boom and bust cycle" of that period, drastically lowering R-squared values. Assuming that type of cycle is not representative of likely future growth in the area, Radian restricted the data set to 1987 and later years. The resulting regressions predicted a 3.2% growth rate for Harris County, and a 2.8% rate for outlying counties. Since these results were very similar to the default assumptions used in

the NONROAD model, and since the R-squared values for both regions were relatively poor (less than 0.6 for both), Radian did not use the results to recalculate the 2007 construction inventory. In addition, the results did not lend support to the contention that activity is shifting to outlying counties. Finally, this approach neglects the significant contribution from public works projects such as road construction. (Details of this analysis are available from Radian upon request.)

Although this cursory analysis did not yield useful results, it is quite possible that more extensive treatment of permit data from A&M and other sources could produce more reliable predictions, both in terms of R-squared values and geographic specificity. In addition, data from key public works departments could be gathered in the 4 to 8 month time frame. City of Houston officials suggested contacting the following entities for related activity data:

- TX DOT
- Houston Metro
- City of Houston
- Port of Houston (good baseline activity data is already available from a previous TNRCC study)
- Harris County
- Corps of Engineers
- Airports
- Major School Districts

It was agreed that data on public works projects should be evaluated separately, given the very different ratio of equipment activity to project dollar values compared to other types of construction. TNRCC staff believe the previous Environ study may be used to estimate weighting factors for these two types of projects, ultimately allowing us to estimate a single growth factor for substitution in the NONROAD model. (Individual factors could be developed for numerous subregions, as the data allows.)

2. Activity Data -- TNRCC has expressed skepticism regarding the use of the NEVES data for estimating both equipment population and annual use data at the local level. The significant difference between NEVES inventories A and B lend support to this contention. In fact, EPA itself recognizes the need for developing site-specific activity data for these sources, and has issued an RFP to the states to develop alternative methodologies for inventory development.

A representative of Haliburton contacted the Harris County Appraisal District to determine if specifics on equipment populations could be obtained. Unfortunately it was determined that the District only maintains highly aggregated equipment value data, which includes all assets for a given firm, not just construction equipment for example. (Dennis Griffith, personal communication, 6/3/99).

Radian subsequently found a reference to the "MacKay Report" in the EPA background documentation on Geographic Allocation Factors in the NONROAD Model. This report supposedly contains survey data on construction equipment of different types, characterizing both population numbers and use patterns (e.g., engine load and hours of use per year). However, the EPA document did not include a specific citation for this source, and EPA staff have not responded to our initial request for a reference. This data may become available for further analysis during the 4 to 8 month time frame. Similarly, results from the recent EPA procurement regarding inventory develop could become available on a limited basis during this period, although the timing is highly uncertain.

While all parties agreed that site-specific equipment population and use data would be highly desirable, no other specific suggestions were made. Note that previous bottom-up inventory efforts under TNRCC contracts have not yielded satisfactory results in this regard (e.g., SAI and Environ studies).

3. Spatial Allocation Surrogates -- TNRCC and others have expressed a desire to update or replace the USGS Land Use surrogates currently employed in the subcounty allocation of construction activity. These surrogates use USGS data from 1990, and land use patterns have shifted significantly since that time. Shifts away from agricultural/rural use are especially prevalent in many of the outlying counties.

Several recommendations were made in this regard. First, H-GAC staff indicated that they have excellent time series data on commercial office space square footage for the entire region. However, this approach necessarily neglects other types of construction, such as industrial, residential, and roads. Second, H-GAC is currently developing detailed land use projections for specific "regional analysis zones" for the year 2020. H-GAC could modify the projections for the target year 2007 using econometric methods for this purpose. This data should be available for further analysis in July. Finally, TNRCC staff indicated that SCAQMD has performed a similar allocation procedure for its PM-10 modeling. TNRCC suggested that someone contact the District for further information. Of these options the second and could might prove worthwhile as part of the 4 to 8 month analysis. In addition, both of these approaches might allow for the estimation of county or subregion-specific growth factors, possibly verifying a shift in activity and emissions away from the center of the modeling area.

4. Temporal Allocation Surrogates -- The NEVES data used as the basis for the construction inventory estimates activity for typical ozone season days. Adjustments could be made for seasonal, weekly, or even daily variations from default assumptions, if site-specific data becomes available. As discussed above, it is likely that the seasonal allocation assumed by EPA overestimates the summertime activity fraction, and underestimates wintertime fractions for Houston. Assuming a uniform distribution throughout the year, spring and fall activity would

also be slightly underestimated as well.[7] However, none of the peer reviewers identified by H-GAC recommended alternative data sources for this information. It was generally agreed that additional survey data would be needed, although this approach had proved unsuccessful in the past.

TNRCC developed day-of-week adjustment factors for construction activity as well, assuming a 30% reduction on Saturdays, and a 70% reduction on Sundays. TNRCC staff acknowledged that there is no data to back up this assumption, which was based solely on engineering judgement. (This compares to a 50% reduction assumed for both days in the NONROAD model, which appears to be based on "common sense" as well.) Again, these factors could also be improved although survey data would be necessary.

Hourly allocations are based on a step-function model, assumed under EPS-2. Before undertaking a detailed survey to obtain this data, TNRCC staff agreed to perform a sensitivity analysis wherein peak-period activity is shifted several hours. If this shift does not produce significant differences in UAM outputs, refinement of this allocation vector would not be warranted.[8]

Aircraft Emissions: Radian agreed to evaluate the emissions reductions resulting from EPA's recently promulgated NOx and CO emission standards for commercial aircraft. These standards, finalized 5/8/97, harmonize U.S. standards with international ICAO requirements, and provide a 16% reduction in NOx levels compared with previous standards (Direct Final Rule, Federal Register, May 8, 1997). However, EPA staff indicated that all engines currently manufactured already meet these levels, and inventory projections should not be affected (Ken Peche, EPA OMS, personal communication, 6/7/99).

Radian also reviewed EPA's recent guidance on emissions inventory development for aircraft, Evaluation of Air Pollutant Emissions from Subsonic Commercial Jet Aircraft, April 1999. This document provides site-specific emissions estimates for both Houston airports that are approximately twice as high as the current TNRCC inventory (~13 vs. 7 TPD of NOx in 2007). Significant differences may be attributable to mixing height variations as well as the emissions estimates used for specific models (e.g., MD-80 emissions are not accounted for directly in the recent EPA guidance.) TNRCC staff indicated that the current inventory uses an acceptable alternative methodology and has already obtained approval from EPA Region 6. However, upon review final emissions impacts are so sensitive to mixing height variations that further evaluation of this factor might be warranted in the 4 to 8 month analysis period. In addition, Radian also provided H-GAC with EPA's guidance for distribution and review, although no comments were received thereafter.

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[7] However, given the previous assumption that September activity was identical to that in the summer months, emissions estimates for this month would still go down relative to the value used in the MCNC analyses.

[8] In addition, documentation from a previous RAQPC memo (dated 1994) indicate that construction interests found work shifts to be highly objectionable, and often infeasible. This memo was provided to TNRCC staff for their reference.

Finally, TNRCC staff indicated that revised activity data might soon be available for the 4 to 8 month analysis, for George Bush International Airport as part of an ongoing contractor study. However, the time frame for completion of this study has not been determined.

Voluntary Measures: As per EPA restrictions, voluntary measures are limited to 3% of total SIP credits for any nonattainment area. For the Houston-Galveston region total credits for such measures would be limited to about 20 – 25 TPD of NOx.

According to TNRCC staff, EPA is about to release official guidance for the quantification of numerous voluntary measures, including engine retrofits, use of alternative fuels, and other programs. (An official workshop will be held in Dallas later in June on this material.) Since these guidelines are not yet officially available, TNRCC has decided not to include any credits for these measures in the current SIP submittal. However, identification and evaluation of such measures could easily be performed in the 4 to 8 month analysis period.

(Note: At the beginning of the two week analysis period Radian was requested to evaluate the creditable emissions benefits associated with accelerated retirement of on and off-road engines. For example, under one proposed modeling scenario on-road emissions would be equivalent to Tier 2 penetration levels in 2015, which would generate very significant reductions. However, since these measures are by their nature strictly voluntary, they are subject to the 3% cap noted above. Therefore Radian did not calculate any emission reductions above and beyond the 3% level, since these would not be creditable in the current SIP.)

Potential Impacts of School Year Shifts: H-GAC provided Radian with a preliminary analysis correlating the incidence of ozone standard violations with the beginning and ending of the school year (see Attachment 3 for a copy of this documentation). According to the thesis, increased VMT directly and indirectly attributable to transportation of children to and from school causes a significant incremental increase in area-wide emissions. The study contends that delaying the start of the school year by three weeks in September could drastically reduce the number and degree of ozone exceedances in Houston, given that a large percentage of total violations occur in early to mid September.

Although the correlation looks compelling, further statistically rigorous analysis would be needed to clearly demonstrate a causal link. Even if such a link is established, there is no mechanism in place that would enable the State to claim credit for any proposed activity shift, since the baseline inventory does not include seasonal adjustments specifically for school induced travel at this time. In addition, EPA currently has no guidance for developing such adjustment factors. Therefore TNRCC, H-GAC and other experts (e.g., TTI) would need to develop a link-based VMT adjustment methodology from scratch. Given the complexity of such an undertaking, it may not be feasible to perform this task within the 4 to 8 month analysis period. In addition, there is no guarantee of EPA approval of credits, especially without a clear demonstration of a causal link.

For these reasons this measure merits further discussion before proceeding. A phased approach may be warranted, first performing more rigorous statistical analyses to demonstrate a causal relationship, and then proceeding with inventory adjustments in conjunction with EPA.

## RECOMMENDATIONS FOR THE 4 to 8 MONTH ANALYSIS PERIOD

Table 2 summarizes all of the potential analyses identified for the 4 to 8 month time frame. All options are listed, regardless of priority or relative feasibility.

**Table 2**
**Potential Analyses for the 4 to 8 Month Time Frame**

| Task | Potential Data Sources |
|---|---|
| Marine Sources: | |
| Evaluate engine retrofit options | EPA guidance on Voluntary Programs, research labs (e.g., Southwest Research) |
| Estimate benefit of clean diesel during hotelling operations | TNRCC EI calculations, Cal ARB emissions benefit estimates |
| Fuel switching for ships | AP-42, EPA for regulatory analysis |
| Update projected inventory | Waterborne Commerce, Lloyd's of London database |
| Estimate reductions from latest federal standards | EPA OMS documentation |
| Construction Sources: | |
| Develop site-specific growth factors | A&M permit data, public works contacts, others (?) |
| Develop site-specific activity factors | EPA's "MacKay Report" (?), upcoming EPA/State studies |
| Update/revise spatial allocation surrogates | H-GAC land use projections for regional analysis zones, SCAQMD methodology for PM-10 modeling |
| Update/revise temporal allocation surrogates | UAM sensitivity analysis results for hypothetical daily activity shift, new surveys, other sources (?) |
| Aircraft/Airport Sources: | |
| Refine mixing height estimates | COAST met data, airport data (?), latest EPA guidance |
| Update activity factor estimates for GBI | Ongoing contractor study |
| Voluntary Measures: | |
| Identify, quantify, and rank options according to cost-effectiveness, public acceptability, etc. | Upcoming EPA guidance |
| School Year Shift: | |
| Statistical validation of causation | Historical HRM data |
| Develop inventory adjustment methodology | Transportation modeling databases, EPA guidance |

Of these measures, the most promising involve refining growth factors and spatial/temporal allocations in order to adjust 2007 UAM results. Also, there is a general consensus to begin moving away from NEVES and toward the use of the new NONROAD model for both base and future year inventory development, although much of this effort will require significant time and resources. Further discussion with TNRCC is merited on this topic.

Given the potentially large credits available for voluntary measures (in absolute if not relative terms), these measures should definitely be evaluated in the 4 to 8 month analysis period. In addition, given the preliminary indications from the H-GAC documentation, school year impacts could be quite significant, even if difficult to demonstrate, and merit further discussion.

Finally, Radian recommends performing a modeling exercise in parallel with the above analyses, specifically designed to estimate when attainment is likely to occur under differing scenarios, due to eventual fleet turnover in the on and off-road sectors. Both MOBILE5b and the NONROAD models could be used for this purpose. Modeling scenarios should include the projected base year, MCNC Scenario 8, and the maximum control scenario as calculated by Radian. In addition, Radian suggests evaluating the likely impacts of the new MOBILE6, especially considering changes in vehicle deterioration rates and OBD2 impacts.

Ozone and NOx Reduction Proposal
School Calendar Change

Submitted to
Regional Air Quality Planning Committee
May 27, 1999

When troubleshooting, one of the first things to do is to look for a pattern in the operating data. If a pattern is found, one then tries to deduce a cause and effect relationship by looking for a common denominator in the data and develop various hypotheses to test with the data. However, one should not let any preconceptions influence the analysis of a problem.

Originally, the objective of reviewing TNRCC's ozone exceedance data was to determine if there could be seasonal control strategies adopted which would be implemented only during those months that ozone exceedances historically occurred. For this analysis ozone exceedance data were downloaded from TNRCC's Web site. Among the data obtained were reports of the ozone exceedances by date and location in 1997, 1998, and 1999 throughout the state of Texas and in the Houston/Galveston region, and they are summarized in the attached table. Based on these data, the conclusion is that the ozone exceedances are seasonal. There were no ozone exceedances in the Houston/Galveston region in the time periods of November through March for 1997, 1998, and 1999.

When the attached table of ozone exceedances in the Houston/Galveston region was developed, another pattern was noticed: an exceptionally high number of ozone exceedances across the state of Texas occurs in August and September. In 1998, almost every day after August 15 had an ozone exceedance in the Houston/Galveston region.

As originally stated, the intended use of the seasonal variation data to suggest that some control measures be required only during those months when ozone exceedances were prevalent. However, the number of late August and early September ozone exceedances were so noticeable that a hypotheses for the cause of so many of them in that time period was developed. The basic question was, "What phenomenon occurs in late August that could cause such an increase in the ozone exceedances?" The answer to the question is, "The beginning of the school year."

Actually, this hypothesis was developed early last April, but was not advanced because there was a probability that the ozone standard would be attained at least in Scenario VIII. However, this is not the case. While the original intent was not to propose a "band aid" for the ozone attainment problem, it is now necessary to provide a more reductions in NOx generation to meet the standard. The following certainly will not be the total solution to the ozone attainment problem, but it may be that little bit extra that is needed to provide compliance.

The proposal is very simple:

Delay the start of the school year until the third week of September.

To analyze this proposal, TNRCC data for one hour ozone concentrations at the Houston Bayland Park monitoring site (C53), 6400 Bissonnet, for the end of the 1997-1998 school year (May 28, 1998) and the start of the 1998-1999 school year (August 17, 1998) of Houston Independent School District were downloaded. This site was chosen because it is located in a predominately residential area on the southwest side of Houston. No heavy industry is near it, but there are some light commercial businesses in the vicinity (Bissonnet between Hillcroft and Fondren). This site should reflect the effects of traffic better than those monitoring stations located in eastern Harris County. This site is also well within the Houston Independent School District boundary, so it would not be affected to any great amount by the different calendars of neighboring school districts.

The data from TNRCC are presented in the attached tables and include the peak ozone, NOx, and temperatures for the two week periods before and after the last day of school and the first day of school in 1998. The most striking information derived from the data are the averages of the peak ozone and NOx readings. These averages were for only the Monday through Friday work week, and holidays and days when rainfall probably occurred were not included. The peak ozone and NOx averages are:

| Time Period | Dates | Ozone | NOx |
|---|---|---|---|
| Two weeks before the last day of school | May 19 - 28, 1998[a] | 61 ppb | 30 ppb |
| Two weeks after the last day of school | May 29 - June 11, 1998 | 43 ppb | 14 ppb |
| Two weeks before the first day of school | August 3 - 16, 1998[b] | 85 ppb | 36 ppb |
| Two weeks after the first day of school | August 17 - 30, 1998[c] | 109 ppb | 84 ppb |

Notes:
a. Does not include Memorial Day Holiday, Monday, May 25, 1998.
b. Does not include probable rain days August 7 and 14, 1998.
c. Does not include probable rain days August 17, 18, and 21, 1998.

No other statistical analysis of the data has been performed other that generating averages, but a cursory look at the data shows the following:

- The were no ozone exceedances in the two weeks prior to the close of school in 1998 while there was one ozone exceedance after the end of the school year. This ozone exceedance occurred on a Sunday and was centered around the Houston Bayland Park monitoring site.

- In the two weeks prior to the start of school in 1998, there were two ozone exceedances that originated in the east Harris County area. There were five ozone exceedences in the two weeks that followed after the start of school including one on a Saturday.

- The peak ozone and NOx data show significantly higher ozone and NOx concentrations for the periods of school days than for the days when school is out.

- The occurrence of the peak NOx concentrations in the weekday mornings is probably caused by a reaction (consumption) of the NOx during the weekday. On weekends, the NOx peaks in the afternoon or evening indicating that something is not reacting with the NOx during the early hours of the day.

- High daily temperature and its time of occurrence is a good indicator for rain; probable rain days were not included in the averages.

The proposal has several positive benefits. First, by taking a large quantity of cars off the road, the amount of NOx generated is significantly reduced. This NOx reduction is at the very time of the year that the conditions are the worst for forming ozone. Also, traffic congestion around the region is reduced in the mornings which is the worst time for generating the NOx that produces ozone.

Unfortunately, modeling this proposed change in the school year is not easy. The easiest approach for modeling would be to simply reduce on road traffic by the number of cars and buses estimated to be involved in transportation of students and teachers to and from schools. For teachers this would be close to a direct one-to-one reduction as most teachers drive to and from their schools. However, there will be less than a one-to-one reduction for students as many either ride buses or even walk to and from school.

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One Hour Ozone Standard Exceedances

| Month | All of Texas | | Houston/Galveston Region | |
|---|---|---|---|---|
| | Site Days | Number of Days | Site Days | Number of Days |
| April 1997 | 1 | 1 | 1 | 1 |
| May 1997 | 3 | 1 | 3 | 1 |
| June 1997 | 11 | 7 | 11 | 7 |
| July 1997 | 9 | 6 | 8 | 5 |
| August 1997 | 12 | 7 | 5 | 3 |
| September 1997 | 19 | 11 | 18 | 10 |
| October 1997 | 3 | 2 | 3 | 2 |
| April 1998 | 6 | 4 | 6 | 4 |
| May 1998 | 8 | 6 | 5 | 5 |
| June 1998 | 2 | 2 | 1 | 1 |
| July 1998 | 8 | 5 | 0 | 0 |
| August 1998 | 32 | 14 | 29 | 13 * |
| September 1998 | 19 | 8 | 14 | 5 |
| October 1998 | 4 | 2 | 4 | 2 |
| December 1998 | 1 | 1 | 0 | 0 |

* Most occurrences were after August 15.

"Site Days" is the total number of days of exceedances for each monitoring site. If two different monitoring sites have exceedances on the same day, then there are two "Site Days." "Number of Days" is simply the different days on which exceedances occurred. If two different monitoring sites have exceedances on the same day, then the"Number of Days" is only one.

Two Weeks Before the End of the
Houston Independent School District 1997-1998 School Year

| Date | Weekday | Ozone Concentration | | NOx Concentration | | High Temperature | |
|---|---|---|---|---|---|---|---|
| | | PPB | Time | PPB | Time | °F | Time |
| May 15, 1998 | Friday | 46.45 | 3:00 PM | 9.2 | 6:00 AM | 88 | 3:00 PM |
| May 16, 1998 | Saturday | 57.49 | 1:00 PM | 10.1 | 8:00 AM | 89 | 2:00 PM |
| May 17, 1998 | Sunday | 63.20 | 5:00 PM | 18.5 | 10:00 AM | 91 | 2:00 PM |
| May 18, 1998 | Monday | 109.77 | 2:00 PM | 62.4 | 7:00 AM | 92 | 2:00 PM |
| May 19, 1998 | Tuesday | 86.08 | 2:00 PM | 55.7 | 6:00 AM | 90 | 3:00 PM |
| May 20, 1998 | Wednesday | 66.16 | 12:00 PM | 31.0 | 6:00 AM | 89 | 3:00 PM |
| May 21, 1998 | Thursday | 50.33 | 11:00 AM | 14.8 | 6:00 AM | 88 | 3:00 PM |
| May 22, 1998 | Friday | 48.32 | 1:00 PM | 9.4 | 6:00 AM | 88 | 2:00 PM |
| May 23, 1998 | Saturday | 54.78 | 1:00 PM | 9.0 | 10:00 PM | 86 | 1:00 PM |
| May 24, 1998 | Sunday | 58.37 | 3:00 PM | 4.5 | 6:00 PM | 89 | 3:00 PM |
| May 25, 1998 | Monday | 28.67 | 3:00 PM | 8.1 | 11:00 PM | 88 | 2:00 PM |
| May 26, 1998 | Tuesday | 41.54 | 1:00 PM | 17.0 | 6:00 AM | 89 | 1:00 PM |
| May 27, 1998 | Wednesday | 45.41 | 3:00 PM | 18.7 | 7:00 AM | 89 | 2:00 PM |
| May 28, 1998 | Thursday | 56.15 | 3:00 PM | 49.4 | 9:00 AM | 94 | 3:00 PM |
| Workday Average (Excludes Memorial Day) | | 61.13 | | 29.7 | | | |
| Weekend/Holiday Average | | 52.50 | | 10.0 | | | |

* One hour ozone standard exceedance.
** Excluded from workday average.

12:00 AM is midnight in the morning of the date; 12:00 PM is noon.

Two Weeks After the End of the
After Houston Independent School District 1997-1998 School Year

| Date | Weekday | Ozone Concentration | | NOx Concentration | | High Temperature | |
|---|---|---|---|---|---|---|---|
| | | PPB | Time | PPB | Time | °F | Time |
| May 29, 1998 | Friday | 96.87 | 3:00 PM | 20.4 | 6:00 AM | 95 | 3:00 PM |
| May 30, 1998 | Saturday | 50.19 | 2:00 PM | 10.5 | 12:00 AM | 96 | 4:00 PM |
| May 31, 1998 | Sunday | 53.16 | 2:00 PM | 13.8 | 5:00 PM | 97 | 4:00 PM |
| June 1, 1998 | Monday | 59.53 | 3:00 PM | 17.5 | 12:00 PM | 96 | 3:00 PM |
| June 2, 1998 | Tuesday | 32.74 | 2:00 PM | 16.5 | 9:00 AM | 94 | 3:00 PM |
| June 3, 1998 | Wednesday | 25.49 | 1:00 PM | 10.3 | 6:00 AM | 91 | 2:00 PM |
| June 4, 1998 | Thursday | 35.52 | 11:00 AM | 10.2 | 6:00 AM | 92 | 3:00 PM |
| June 5, 1998 | Friday | 56.22 | 1:00 PM | 19.9 | 9:00 PM | 92 | 2:00 PM |
| June 6, 1998 | Saturday | 35.10 | 12:00 PM | 16.9 | 7:00 PM | 77 | 12:00 PM |
| June 7, 1998 | Sunday | 129.93 * | 1:00 PM | 19.1 | 9:00 AM | 86 | 2:00 PM |
| June 8, 1998 | Monday | 40.35 | 2:00 PM | 8.4 | 6:00 AM | 90 | 3:00 PM |
| June 9, 1998 | Tuesday | 37.84 | 3:00 PM | 16.7 | 6:00 AM | 93 | 2:00 PM |
| June 10, 1998 | Wednesday | 25.75 | 5:00 PM | 9.1 | 6:00 AM | 93 | 2:00 PM |
| June 11, 1998 | Thursday | 22.21 | 11:00 AM | 12.4 | 6:00 AM | 92 | 12:00 PM |
| Workday Average | | 43.25 | | 14.1 | | | |
| Weekend Average | | 67.10 | | 15.1 | | | |

* One hour ozone standard exceedance.

** Excluded from workday average.

12:00 AM is midnight in the morning of the date; 12:00 PM is noon.

Two Weeks Before the Start of the
Houston Independent School District 1999-1999 School Year

| Date | Weekday | Ozone Concentration | | NOx Concentration | | High Temperature | |
|---|---|---|---|---|---|---|---|
| | | PPB | Time | PPB | Time | °F | Time |
| August 3, 1998 | Monday | 162.67 * | 2:00 PM | 26.4 | 6:00 AM | 98 | 2:00 PM |
| August 4, 1998 | Tuesday | 148.81 * | 2:00 PM | 25.0 | 6:00 AM | 98 | 2:00 PM |
| August 5, 1998 | Wednesday | 91.94 | 2:00 PM | 30.9 | 6:00 AM | 97 | 2:00 PM |
| August 6, 1998 | Thursday | 57.91 | 12:00 PM | 48.7 | 6:00 AM | 93 | 4:00 PM |
| August 7, 1998 | Friday | 34.94 ** | 11:00 PM | 40.5 | 8:00 PM | 82 | 5:00 PM |
| August 8, 1998 | Saturday | 47.48 | 3:00 PM | 31.9 | 6:00 AM | 95 | 4:00 PM |
| August 9, 1998 | Sunday | 47.02 | 1:00 PM | 19.1 | 5:00 AM | 96 | 2:00 PM |
| August 10, 1998 | Monday | 46.72 | 1:00 PM | 32.4 | 6:00 AM | 97 | 3:00 PM |
| August 11, 1998 | Tuesday | 63.86 | 3:00 PM | 28.3 | 6:00 AM | 98 | 3:00 PM |
| August 12, 1998 | Wednesday | 66.59 | 3:00 PM | 64.5 | 6:00 AM | 98 | 3:00 PM |
| August 13, 1998 | Thursday | 40.45 | 3:00 PM | 30.0 | 6:00 AM | 96 | 1:00 PM |
| August 14, 1998 | Friday | 32.77 ** | 12:00 PM | 45.8 | 2:00 PM | 89 | 10:00 AM |
| August 15, 1998 | Saturday | 112.63 | 2:00 PM | 61.4 | 6:00 AM | 92 | 3:00 PM |
| August 16, 1998 | Sunday | 45.31 | 1:00 PM | 30.1 | 12:00 AM | 90 | 1:00 PM |
| Workday Average | | 84.87 | | 35.8 | | | |
| Weekend Average | | 63.11 | | 35.6 | | | |

* One hour ozone standard exceedance.

** Excluded from workday average.

12:00 AM is midnight in the morning of the date; 12:00 PM is noon.

Two Weeks After the Start of the
Houston Independent School District 1999-1999 School Year

| Date | Weekday | Ozone Concentration | | NOx Concentration | | High Temperature | |
|---|---|---|---|---|---|---|---|
| | | PPB | Time | PPB | Time | °F | Time |
| August 17, 1998 | Monday | 33.22 ** | 11:00 AM | 107.5 | 8:00 PM | 90 | 10:00 AM |
| August 18, 1998 | Tuesday | 48.36 ** | 11:00 AM | 99.7 | 6:00 AM | 89 | 10:00 AM |
| August 19, 1998 | Wednesday | 136.49 * | 2:00 PM | 142.0 | 6:00 AM | 94 | 4:00 PM |
| August 20, 1998 | Thursday | 127.23 * | 1:00 PM | 78.1 | 7:00 AM | 94 | 3:00 PM |
| August 21, 1998 | Friday | 39.39 ** | 11:00 AM | 54.5 | 6:00 AM | 57 | 11:00 AM |
| August 22, 1998 | Saturday | 20.93 | 2:00 PM | 36.9 | 8:00 PM | 82 | 3:00 PM |
| August 23, 1998 | Sunday | 45.98 | 4:00 PM | 39.1 | 2:00 AM | 86 | 4:00 PM |
| August 24, 1998 | Monday | 60.20 | 1:00 PM | 100.3 | 6:00 AM | 89 | 4:00 PM |
| August 25, 1998 | Tuesday | 51.44 | 12:00 PM | 81.6 | 7:00 AM | 92 | 2:00 PM |
| August 26, 1998 | Wednesday | 73.78 | 4:00 PM | 87.6 | 6:00 AM | 93 | 3:00 PM |
| August 27, 1998 | Thursday | 170.55 * | 5:00 PM | 55.6 | 6:00 AM | 95 | 3:00 PM |
| August 28, 1998 | Friday | 146.42 * | 5:00 PM | 39.8 | 6:00 AM | 96 | 4:00 PM |
| August 29, 1998 | Saturday | 167.01 * | 3:00 PM | 44.1<br>(24.8) | 11:00 PM<br>(6:00 AM) | 99 | 2:00 PM |
| August 30, 1998 | Sunday | 123.05 | 10:00 AM | 38.5 | 12:00 AM | 89 | 1:00 PM |
| Workday Average | | 109.44 | | 83.6 | | | |
| Weekend Average | | 89.24 | | 39.7 | | | |

* One hour ozone standard exceedance.
** Excluded from workday average.

12:00 AM is midnight in the morning of the date; 12:00 PM is noon.